

Lateral Approach to the Maxillary Sinus and Mandibular Canal in Severely Atrophied Posterior Alveolar Bone

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Purpose: To present a technique to rehabilitate atrophied alveolar ridges in the posterior maxilla and mandible using bone lateral to the maxillary sinus and to the inferior alveolar nerve and to present a retrospective study of the technique. **Materials and Methods:** Severe resorption of the posterior region of the maxilla and mandible was treated following a conservative approach. Patients who presented this bone crest condition that impeded the placement of implants and had an anatomy that allowed the inferior alveolar nerve or the maxillary sinus to be approached laterally were treated. The bone ridge thickness lateral to the maxillary sinus and the inferior alveolar nerve was measured by computed tomography, and implants with a wedge-shaped design were placed in the available bone. A retrospective review of clinical records of these patients, treated between 1998 and 2012 at the Clinest - Clinical Center of Research in Stomatology, was conducted. The studied variables were surgical and prosthetic complications, the implant survival rate, and the difference between the remaining bone ridge measurement in the ridge center and the implant length placed laterally. **Results:** Fifty-six patients met the inclusion criteria. These patients received 208 implants according to the aforementioned technique. The mean implant length gain was 6.9 mm, varying from 0.5 to 12 mm. The cumulative survival rate was high for both maxillaries. For the implants placed beside the inferior alveolar nerve, none were lost at 2 years, two were lost at 5 years, and four were lost at 10 years. For the implants placed beside the maxillary sinus, only four implants were lost at 10 years. Nerve injuries and surgical/prosthetic complications occurred but were not significant. **Conclusion:** The use of available bone alongside the maxillary sinus and inferior alveolar nerve to place implants is a surgical possibility, and a predictable, safe approach, albeit delicate and experience-dependent. INT J ORAL MAXILLOFAC IMPLANTS 2018;33:412–418. doi: 10.11607/jomi.5941

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The posterior segments of the maxilla and the mandible are vulnerable to resorption, which reduces the alveolar bone height by reducing the distance from the bone crest to the maxillary sinus or to the inferior

alveolar nerve. When this occurs, implant placement possibilities are reduced.^{1–13}

According to the standard protocol of implant placement, implants are placed in the middle of the bone crest, directly over the inferior alveolar nerve or maxillary sinus. Short alveolar bone height reduces the chance of implant placement considerably in this way; however, a great amount of bone where implants could be placed is usually available lateral to these anatomical structures. Computed tomography can be used to display how much bone is available lateral to the inferior alveolar nerve and the maxillary sinus. Even before the advent of computed tomography, this lateral bone was used to place implants.^{14,15}

Whenever the maxillary sinus or the inferior alveolar nerve limits the placement of regular implants, short implants can be used. An increasing number of reports have shown satisfactory success rates for short implants (length < 8.5 mm),^{5,16–19} but studies still demonstrate that long implants should be the primary option.^{10,12,20,21}

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Wedge-shaped implants, mainly angled,^{3,4,6,22–25} allow for the placement of implants in restricted spaces, especially those areas in which the angulation of the bone ridge was altered by resorption.

The applicability of these implants has reached levels of 92.7%,⁶ and their biomechanical behavior has also been tested in different studies with favorable results.^{4,22–24}

The cumulative survival rates of these implants at 5 and 10 years were 96.6% and 91.8%, respectively, even in poor bone conditions,²⁵ which are consistent with those data obtained for other implant systems.²⁶

The aim of this work was to describe a technique to treat severely atrophied alveolar ridges in the posterior maxilla and mandible using the available bone beside the maxillary sinus and the inferior alveolar nerve by using both straight and angled wedge-shaped implants. Additionally, this work aimed to define, in a studied group, implant length gain provided by a lateral approach when compared with a traditional approach and also define the implant survival rate.

MATERIALS AND METHODS

A retrospective review was conducted of clinical records of patients treated with wedge-shaped implants placed lateral to the maxillary sinus and the inferior alveolar nerve. This review included patients treated between 1998 and 2012 at the Clinest - Clinical Center of Research in Stomatology. All the patients had severe resorption of the posterior region of the maxilla and mandible, with the bone crest condition impeding the placement of implants, and had an anatomical condition that allowed the inferior alveolar nerve or the maxillary sinus to be approached laterally. The bone ridge thickness lateral to the maxillary sinus and the inferior alveolar nerve was measured by computed tomography, and both straight and angled wedge-shaped implants (Fig 1) were used (Maxform implant - BiomecMed).

The studied variables were surgical and prosthetic complications, the implant survival rate, and the difference between the remaining bone ridge measurement in the ridge center and the implant length placed laterally. Only the reviewers had access to the records and to the database so that patients' identities were protected.

The inclusion criteria for review were as follows: patients who had an atrophied posterior maxilla or mandible that impeded the insertion of implants of at least 9 mm long in the crest center and had wedge-shaped implants placed lateral to the inferior alveolar nerve or the maxillary sinus without bone augmentation, sinus elevation, or nerve deviation.

The exclusion criteria were as follows: records without a signed informed consent form allowing use of the

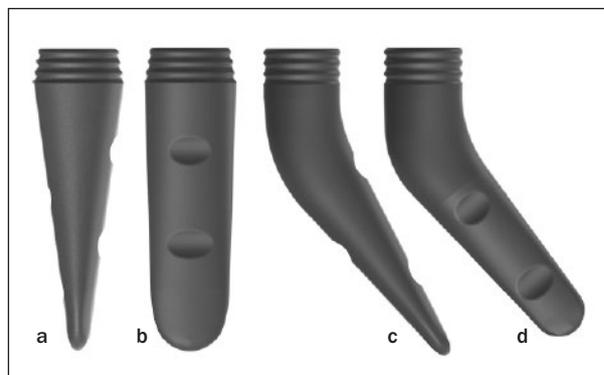


Fig 1 Wedge-shaped implants. Straight implant (Ø4.0 mm): (a) lateral view; (b) frontal view. Frontal angled implant (Ø3.3 mm): (c) lateral view. Lateral angled implant (Ø3.3 mm): (d) frontal view.

data on research and case reports; missing information about any variable; and information that was inconsistent, confusing, or subject to double interpretation.

The implant data forms were originally filled out in a digital format. The forms were synchronized with a database (Excel, Microsoft), which was then synchronized with the statistical program, eliminating the risk of changes in data during transfers. The dependent variable was implant failure (implant survival rate), defined as complete removal of the implant for any reason. The survival duration was calculated from the date of implant placement to the date of the last follow-up, which in the case of failures was implant removal.

Other variables studied were surgical and prosthetic complications, the remaining bone crest height beneath the maxillary sinus and above the inferior alveolar nerve on the crest center (which is usually considered as the bone available for implant placement), and the difference between this remaining bone ridge measurement and the implant length placed laterally. These last data were used to evaluate the implanted material gain allowed by the use of the lateral bone available in those places.

Treatment Technique

At the time of treatment, cone beam computed tomography (CBCT) scans were obtained and analyzed to determine bone shape and bone dimension around the maxillary sinus and the mandibular canal (Figs 2a, 2b, 3a, and 3b). Straight, wedge-shaped implants were usually used when the implant abutment was able to be placed parallel to adjacent teeth or other implants, and frontal angled implants were used to compensate for implant tipping (Figs 4a, 4b, 5a, 5b, and 5c). The frontal angled implant has three degrees of angulation (25, 35, and 45 degrees), and the degree of angulation used was dependent on the alveolar bone inclination (Fig 6). Some mandibular inclinations allow a satisfactory prosthetic position of the implant platform using straight implants (Fig 7). The preoperative,

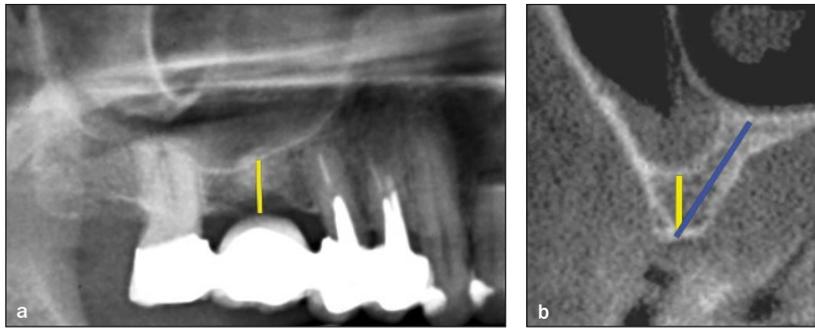


Fig 2 Radiography of the maxilla showing the sinus and the alveolar bone available. (a) Lateral view, panoramic. Bone under the sinus usually considered for implant placement (yellow line). (b) Transaxial view. Available bone, laterally to the sinus, sufficient to receive implant (blue line).



Fig 3 Radiography of the mandible showing the mandibular canal trajectory and the available alveolar bone. (a) Lateral view, panoramic: bone over the mandibular canal considered for implant placement (yellow line). (b) Transaxial view: bone over the mandibular canal considered for implant placement (yellow line) and available bone laterally to the canal, with sufficient amount to receive implant (blue line).

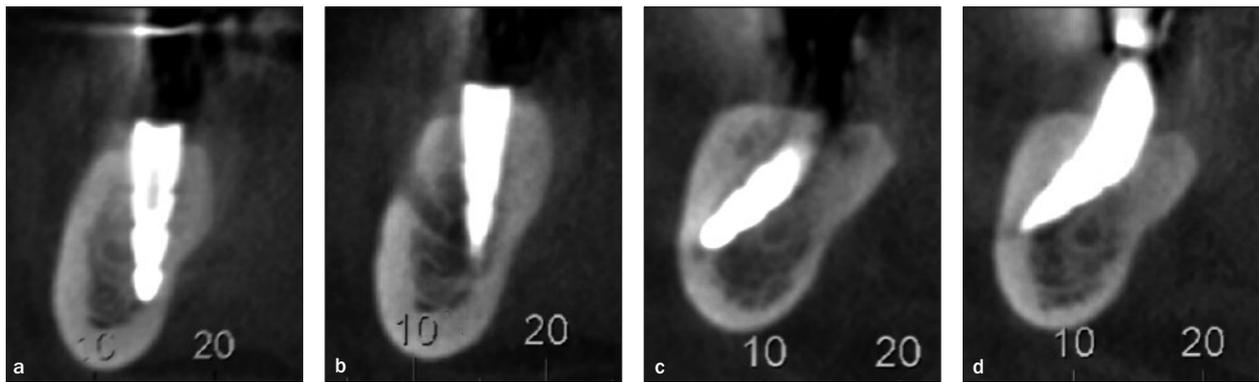


Fig 4 Implants placed laterally to the inferior alveolar nerve. (a,b) Straight implant placed lingually to the inferior alveolar nerve close to the mental foramen. (c,d) In another situation, to compensate the inclination, angled implants were used buccally. In both situations, the implants were beyond the canal, the inferior alveolar nerve was preserved, and the parallelism of the prosthetic abutment was reached. CBCT: transaxial view.

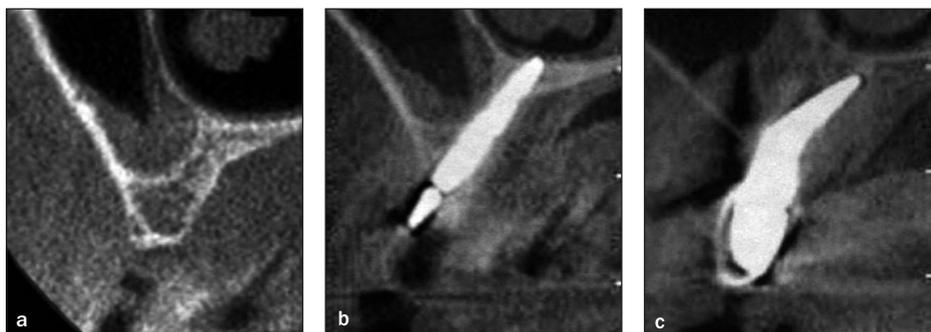


Fig 5 Implants placed laterally to the maxillary sinus. (a) Remaining atrophied bone ridge showing only 4 mm height in the center of the crest. (b) Straight implant, 15 mm long, placed in the palatine bone. (c) Angled implant of 13 mm, placed in the same bone conditions. The angle of the implant compensates the necessity of palatine inclination. CBCT: transaxial view.

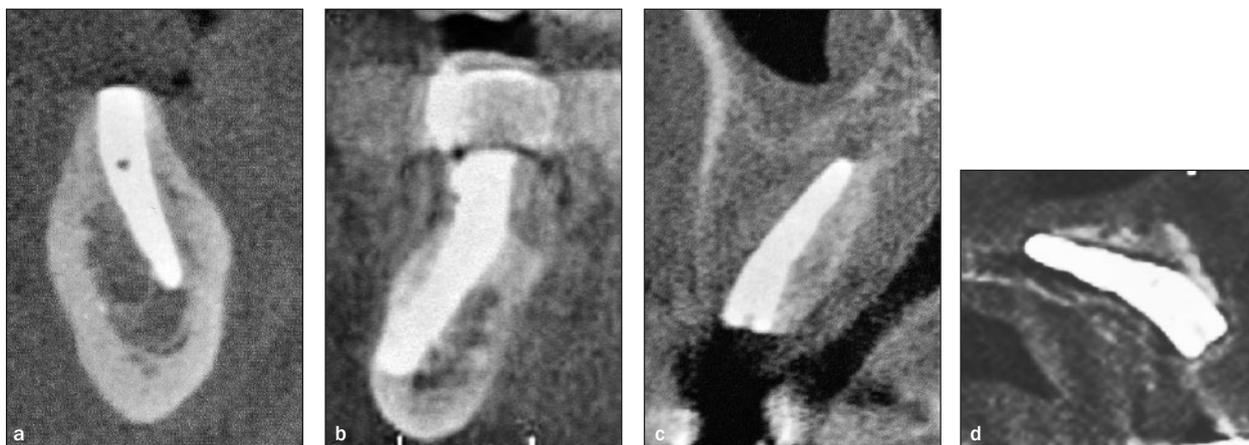


Fig 6 Angled implants placed to compensate bone anatomy and implant inclination: (a, b) mandible; (c, d) maxilla.

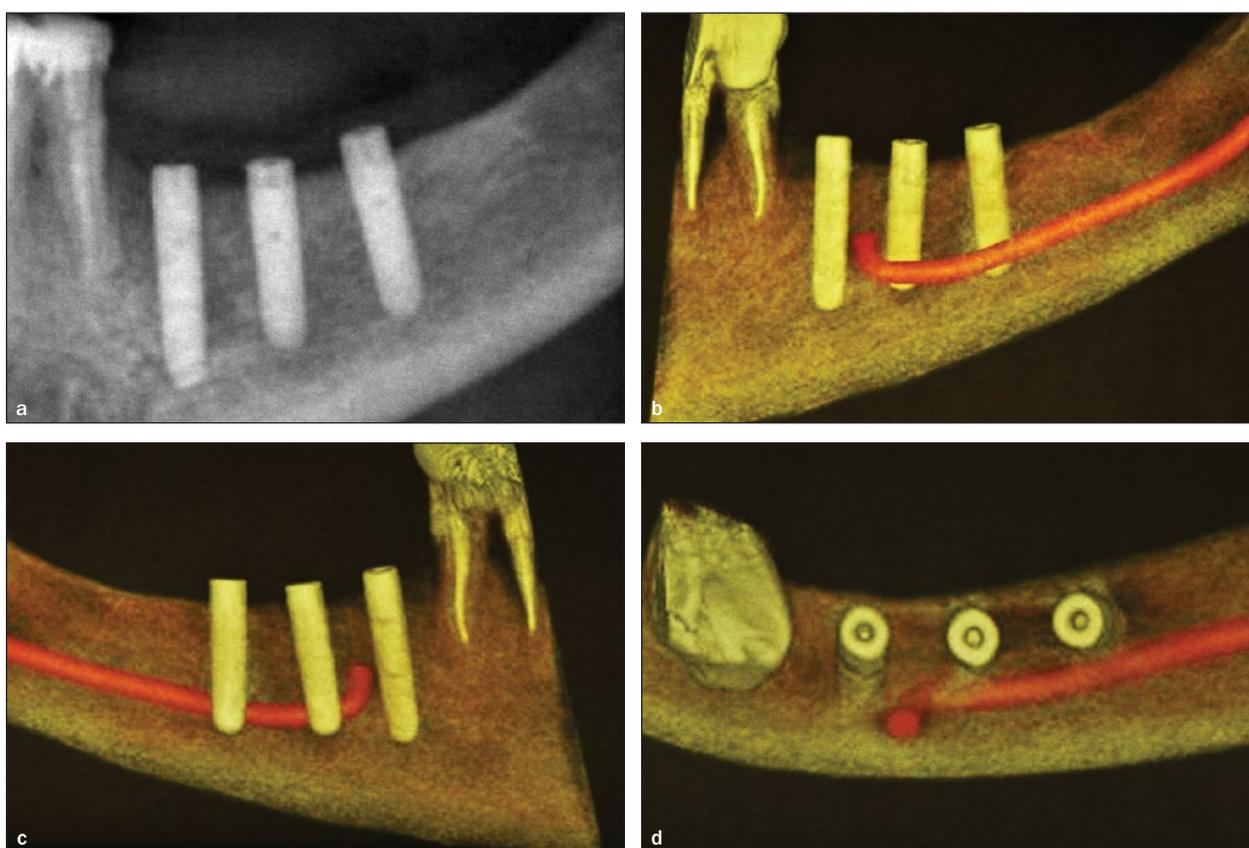


Fig 7 Three implants of 15 mm long were placed in the posterior region. The proximal implant, mesial to the mental foramen, was placed in the center of the crest, and the two distal implants were placed lingually to the inferior alveolar nerve. (a) Panoramic radiographic view. Tridimensional reconstruction: (b) buccal (c) lingual, and (d) occlusal views.

transoperative, and postoperative protocols were based on standard medication guidelines for implant placement. Local anesthesia was achieved through an inferior and superior alveolar block and through infiltrative injections.

Extensive full-thickness surgical flaps with relaxing incisions at the extremities were performed in all cases. The entire lateral view of the mandible or maxilla, on which the implant is placed, is important to guide

the preparation of the implant bed and avoid injury to adjacent tissues. The implant sites were located by the surgical guide. No surgery was performed using a restrictive surgical guide created from CBCT.

An implant drill, 1.6 mm in diameter, was used to prepare the implant layer (PLB 016 - ISO 500 206 408298 016 BiomecMed). The drill was mounted at a contra-angle of 1:1 at 35,000 rpm, with a torque of 50 Ncm and with an irrigation of 50 mL/minute. The drilling always started

in the center of the bone crest and advanced along the buccal or lingual (palatine) surface (guided by the inclination of the surface).

In cases where angled implants were used, drilling was done along the cortical surface, chosen to receive the implant, on the buccal or lingual side. This drilling was straight to receive the apical two-thirds of the angled implant. After assaying the drilling with the analog straight implant, another cut was done perpendicular to the alveolar ridge plane of 4 mm deep, providing space for the implant coronal third.

The analog was introduced, to assay the implant bed, until its length reference mark reached the bone level. The implant was then placed, and the final position was established by percussion. The cover screw, coated with a filler antiseptic material indicated to control the bacterial growth in the inner ambient of the implants (Proheal - BiomacMed), was then screwed into the implant. At the reentry surgery, the transmucosal abutment was placed (also covered with Proheal), followed by a healing period of 30 days. All implants received provisional cemented prostheses until the porcelain prostheses were delivered as the definitive restoration. All patients were treated by the same experienced oral surgeon and two experienced prosthodontists.

Statistical Analysis

The information gathered from the dental records was the implant survival, the height of the residual bone crest, the length of the implant placed, and the surgical/prosthetic complications. The principal statistical variable (and dependent variable) was implant failure, defined as the removal of the implant for any reason. Implant survival as a function of time was analyzed using the Kaplan-Meier method.

Cumulative proportion survival analysis was performed using life tables (actuarial). Cox proportional-hazards regression analysis modified for correlated dependent observations was also used, with the implant as the unit of analysis. Significance was set at $P < .05$ ($\alpha = 5\%$). All statistical analyses were conducted using STATA.13 software, and the graphics were developed in SPSS 22.0 software.

For every implant site, the alveolar bone height was measured on the initial tomography and compared with the implant length placed. This study was conducted in accordance with the Helsinki Declaration,²⁷ and the study report was structured following the STROBE Statement for observational studies.²⁸

RESULTS

In this study, 56 records met the inclusion criteria and were selected. The median age of the patients was

55.17 ± 11.33 years. Women represented 59% ($n = 33$) and men represented 41% ($n = 23$) of the subjects. The patients received 73 implants placed beside the maxillary sinus and 135 implants beside the inferior alveolar nerve.

A statistically significant difference ($P = .001$) was found between the available bone height measurement in the center of the crest and the implant length placed. Considering both arches, the mean remaining bone height was 7.1 mm, and the mean placed implant length was 14 mm. The range of implant length gain in both arches was from 0.5 to 12 mm (mean: 6.9 mm).

Seventy-eight of the implant sites had an alveolar bone height ≤ 6.1 mm, either below the maxillary sinus or above the inferior alveolar nerve, yet 203 implants of a total 208 implants placed were ≥ 13 mm long. Only five implants were 11 mm long. Seven implants were 17 mm long, of which, four were placed in the maxilla and three were placed in the mandible. All the implants were 3.3 mm in diameter.

Some cases had less than 4 mm of bone crest above the inferior alveolar nerve or below the maxillary sinus, and still, long implants were placed beside them.

The cumulative survival rate was high for both maxillaries. For the 135 implants placed beside the inferior alveolar nerve, none were lost at 2 years, two were lost at 5 years, and four were lost at 10 years. For the 73 implants placed beside the maxillary sinus, four implants were lost only at 10 years.

Special attention was paid to any signs of impaired function of the inferior alveolar nerve or of any sinus problem. Ten patients experienced a light to moderate paresthesia that resolved spontaneously after 7 to 90 days. Complications involving the maxillary sinus were not observed or reported by the patients. Surgical and prosthetic complications were similar to those encountered in procedures with a sufficient amount of bone to place regular implants over the crest center, such as edema, pain, lack of parallelism, difficulty of abutment preparation, screw or crown loosening, etc. No exceptional incident was registered in the patient clinical records.

DISCUSSION

This work describes a technique that uses wedge-shaped implants to rehabilitate severely atrophied alveolar ridges in the posterior maxilla and mandible utilizing the available bone lateral to the maxillary sinus and to the inferior alveolar nerve. It also analyzes the implant survival rates, the gain of the implant length, and surgical/prosthetic complications of a cohort of patients treated with this technique.

The rationale for this technique is based on the frequent availability of residual bone lateral to the

maxillary sinus and the inferior alveolar nerve, and on the design of the straight and angled wedge-shaped implant, which allows placement in narrowed bones.

The retrospective study included 135 implants placed in the mandible and 73 implants placed in the maxilla, with high implant survival rates over a long period of time. The patients included in the present study were treated by professionals experienced in oral surgery and prosthodontics, a factor that might have contributed to these high success rates.

All implants were placed in accordance with the general guidelines for implant surgeries. Surgical procedures and patient follow-up were very similar for all individuals. Therefore, there was uniformity in the study sample, since the implants were placed within the same parameters of diagnosis, planning, and surgical conditions, and the procedures were performed in the same operating room. This might have produced some bias, and further studies should be conducted to eliminate this uniformity. However, the sample was heterogenic, as patients were chosen randomly, and patient characteristics and clinical conditions were largely varied concerning age, clinical history, periodontal status, etc, which reflected the clinical quotidian reality.

A weakness to be considered in this study is the small number of patients. Thus, the data obtained to the variables studied should be considered with caution.

The mean implant length gain for both maxillaries was 6.9 mm, varying from 0.5 to 12 mm. The residual bone available lateral to the maxillary sinus and the inferior alveolar nerve of the severely absorbed crest was used to place implants.

Coadjuvant procedures such as bone grafting, sinus elevation, or nerve deviation do not need to be employed, thus reducing morbidity and cost. These aspects improve the patient's adherence to treatment.

Two patients noted mild paresthesia that resolved spontaneously in 7 to 30 days, and seven patients had moderate paresthesia that resolved spontaneously in 30 to 90 days. These findings suggested that in the lateral approach, the anatomical parameters, such as the bone buccal or lingual surface, offered a safe guide, which reduced the risk of nerve damage or sinus perforation. This, in addition to the experience and skill of the operator, was likely the reason for the low paresthesia rates and sinus complications found in this work. Sinus complications were not reported, even in the cases where the implant extended into the antrum.

Prosthetic procedures were not altered by the technique and followed the regular parameters for implant dentistry prostheses.

The technique was also successful in using long implants, even in areas with short bone height and a thinned crest. In 78 sites, the bone height was ≤ 6.1 mm.

If the minimum implant length was 5.0 mm (short implant) and the minimum safety margin of 1.0 mm was necessary in those 78 sites, placement of cylindrical or conical short implants with a standard approach may not have been feasible. However, all patients received long implants with a mean length of 13.9 mm.

Short implants, which are an alternative therapeutic procedure in these clinical situations, have medium or large diameters, so even if the bone were sufficient in height, their dimensions would preclude their placement in thin, atrophied bone crests.

Even considering short implants a viable alternative in these cases, the use of long implants should be the first therapeutic choice.^{13,26} Perelli et al¹⁹ reported an 84% survival rate in 5 years for implants of 5 and 7 mm long, and Anitua et al¹² reported survival rates of 98.2% for a short period of 26 months for short implants (5.5 and 6.5 mm long). It is a good success rate, but this work showed sufficient bone thickness lateral to the maxillary sinus and inferior alveolar nerve to place long implants, which can improve the load distribution and the biomechanical resistance of the implant and the prostheses.^{10,13,26} Moreover, long implants have a longer life expectancy, when successive episodes of peri-implantitis occur, with successive bone loss. Comparatively, the short implant has, in this case, a worse clinical condition and worse prognosis.

Also, in this work, in the majority of the cases, the amount of bone lateral to the maxillary sinus and inferior alveolar nerve was sufficient to receive conventional, narrow screwed implants. Thus, although this was not the goal of this work, the results can be somehow extrapolated to the use of narrow screwed implants in these cases.

Another alternative could be the use of onlay bone grafting, but it is a less reliable option with lower success rates, especially for bone height gain. It also requires a donor site, which increases morbidity and cost, and reduces patient adherence to treatment. Guided regeneration can also be considered, but in the same way, the procedure is more laborious and good results are less certain, especially when it comes to vertical bone formation in the bony crest.⁶

As demonstrated in the study, the technique described could be a viable alternative in the treatment of an atrophied posterior alveolar bone crest in the maxilla and mandible. However, this is a sensitive and experience-dependent technique that requires a learning process, and also involves surgical risks. In the lateral approach without the use of a surgical restrictive guide, the risks are more controlled than in the central approach, which places the implant directly over the inferior alveolar nerve or the maxillary sinus, because the surgeon can use the lateral faces of the maxillaries to guide the drill and avoid the anatomical

structures. Cruz and Reis¹⁴ related that, in that work, placing implants lateral to the inferior alveolar nerve reduced nerve injuries. The use of a restrictive surgical guide also could reduce risks.

Further studies focusing on this field, in aspects such as the biomechanical behavior of the implants,^{4,23,24} the placement of screwed implants lateral to the maxillary sinus or the inferior alveolar nerve, the use of a restrictive surgical guide created from CBCT, and a large number of patients, could generate more evidence and safety for wide clinical application of the technique.

CONCLUSIONS

Within the limitations of this study, which included a small number of patients, the following conclusions can be drawn.

The available bone lateral to the maxillary sinus and the inferior alveolar nerve is a viable possibility for wedge-shaped implant placement and can contribute to the rehabilitation of patients with severely atrophied posterior regions of the maxilla and mandible. The overall survival of the implants placed in this condition was excellent, and the design of the implants used was feasible for use in long-term treatment. The technique is a conservative, predictable, and secure approach, which decreases surgical complexity and morbidity, allows the use of longer implants, increases implant therapy applicability, and saves money and time. However, it is a sensitive and experience-dependent technique that requires a learning process, and has surgical risks concerning the maxillary sinus and the inferior alveolar nerve that must be considered.

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